Extracting Coherent Information from Noise Based Correlation Processing

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LONG-TERM GOALS

The goal of this research is to establish methodologies to utilize ambient noise in the ocean and to determine what scenarios are best suited for applying these methods.

OBJECTIVES

Because noise-based correlation processing is based on equilibrium related stationary statistics, the ocean does not really provide a cooperatiing scenario for such processing. The objectives of this research is to develop array and signal processing that overcome the effects of the fluctuating ocean by essentilly developing techniques that speed up the processing to time scales shorter than those of ocean fluctuations.

APPROACH

The approach has been a combination of experiment/data analysis and the development of appropriate signal processing methods.

WORK COMPLETED

We have published two papers on ocean noise. The JASA paper, in addition to reporting shallow water results already previously stated included a result in which time intervasls for the correlations were selected based on noise directionality. These results indicated that higher SNR's were achievable then by including all the data. The second paper was a GRL letter in which acoustic noise data of opportunity was selected from the Diego-Garcia CTBT IMS hydroiacoustic triad in the Indian Ocean and converted to vector quantities and then favorably compared with land seismometers. Each of the above papers were part of the PhD work from two students.

RESULTS

Selected time intervals:Here we have shown that selecting correlation intervals corresponding to ships in the endfire lobes increases the SNR even though less data is used.

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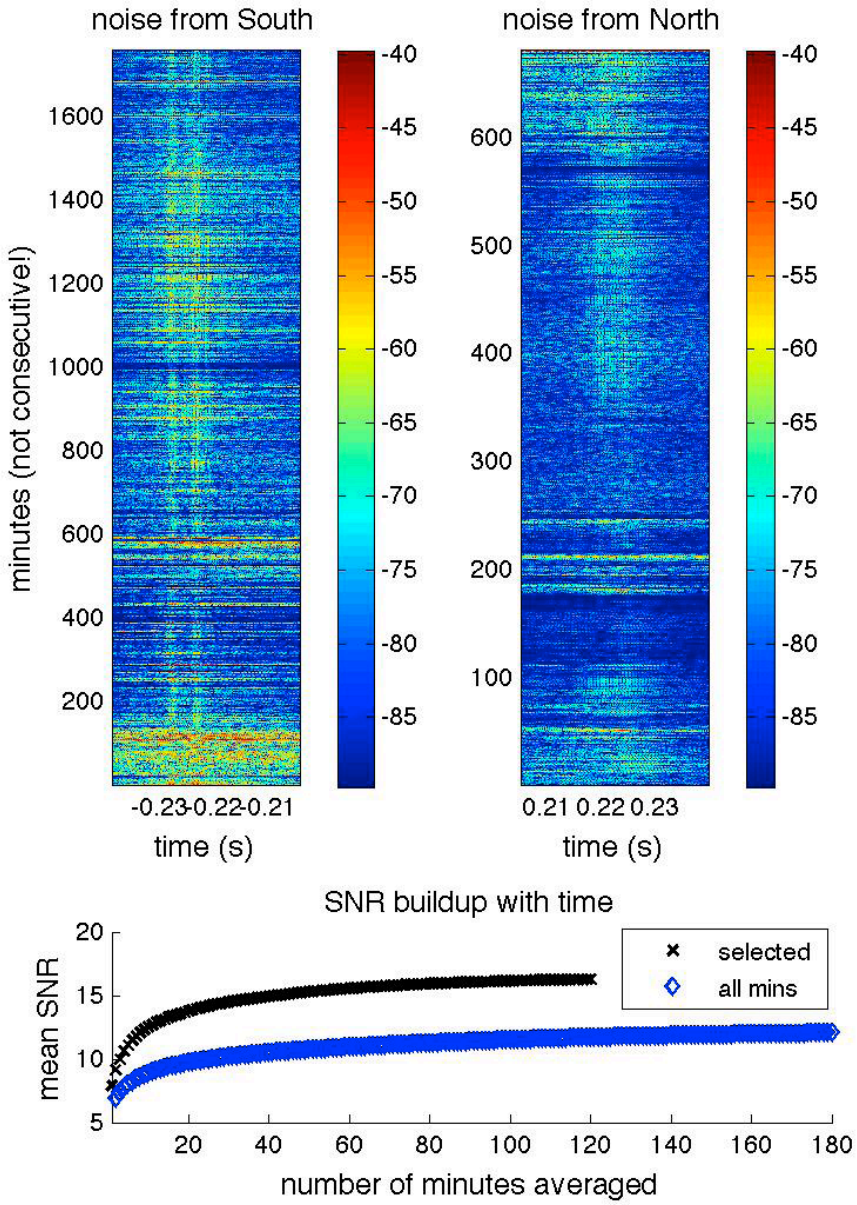
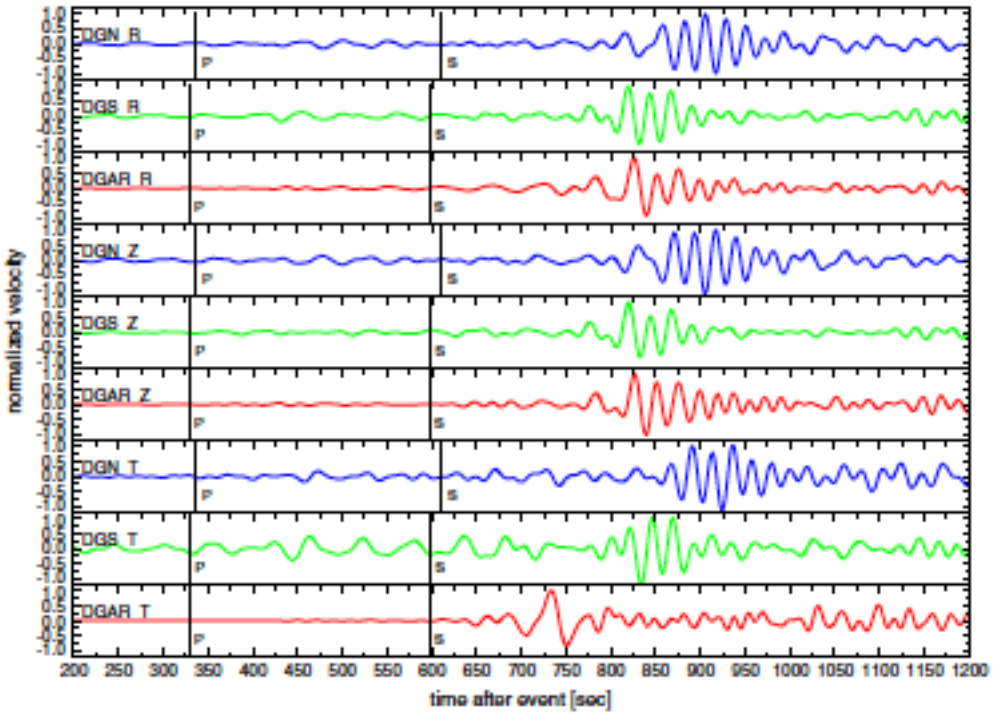


This figure shows selected single minute correlations, chosen when the power from the given direction (north or south) was greater than an arbitrarily chosen threshold (chosen in this case as 0.1). Top plots are of the correlation where each horizontal line is a one minute correlation, but the minutes (vertical axis) are not contiguous. The horizontal axis is the correlation time, showing only the times around the expected peak arrival time in positive (right plot) or negative (left plot) time. The intensity is shown in dB. The right and left plots are independent of each other. The bottom figure shows the build up of the SNR for the correlation minutes selected above, due to noise from the South. The top (x) line shows the average SNR for increasing number of averaged minutes correlation; the bottom (diamonds) line is the same for the non-selected correlations [1].

CTBT result: The acoustic data is from the 2004 Great Sumatra earthquake as monitored on the IMS triad array in the Indian Ocean. The seismic data is from a land station on Diego Garcia. The vertical and radial acoustic derived results show agreement with seismic whereas, as expected the transverse (Love Wave) does not couple into the water column [2].



This figure shows ydroacoustic and seismic data of f =0.01–0.05 Hz plotted using the Seismic Analysis Code (SAC). R: Radial, Z: Vertical, T: Transverse. (top) Blue lines represent the DGN hydroacoustic data, (middle) green lines represent the DGS hydroacoustic data, and (bottom) red lines represent the DGAR seismic data. The x-axis corresponds to the time after event [200–1200 s]; y-axis corresponds to normalized velocity. Arrival times of P and S waves calculated using TauP are indicatedas black vertical lines on each time series.

IMPACT/APPLICATIONS

The potential impact of this research is directed toward developing passive methods to study ocean environmental acoustics.

RELATED PROJECTS

None

PUBLICATIONS

[1] Stephanie Fried, S.C. Walker, W. S. Hodgkiss and W. A. Kuperman “Measuring the effect of ambient noise directionality and split-beam processing on the converence of the cross-correlation function,” J. Acoust. Soc. Am. 134, 1824-1832 (2013).

[2] Selda Yildiz, K. Sabra, L.M. Dorman, and W. A. Kuperman “Using hydroacoustic stations as water column seismometers,” GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 2573–2578, doi:10.1002/grl.50371, 2013